Met Office AIRS Assimilation and Impact Assessment Plan

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Acknowledgements

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Met Office NWP Models

	Horizontal Resolution	Horizontal Grid EW x NS	Vertical Levels
Global Forecast	0.83° x 0.56°	432 x 325	30
UK Mesoscale	12km	146 x 182	38
HADAM4	2.50° x 3.75°	96 x 73	38

Table 1: Resolutions used by main UM atmospheric configurations.
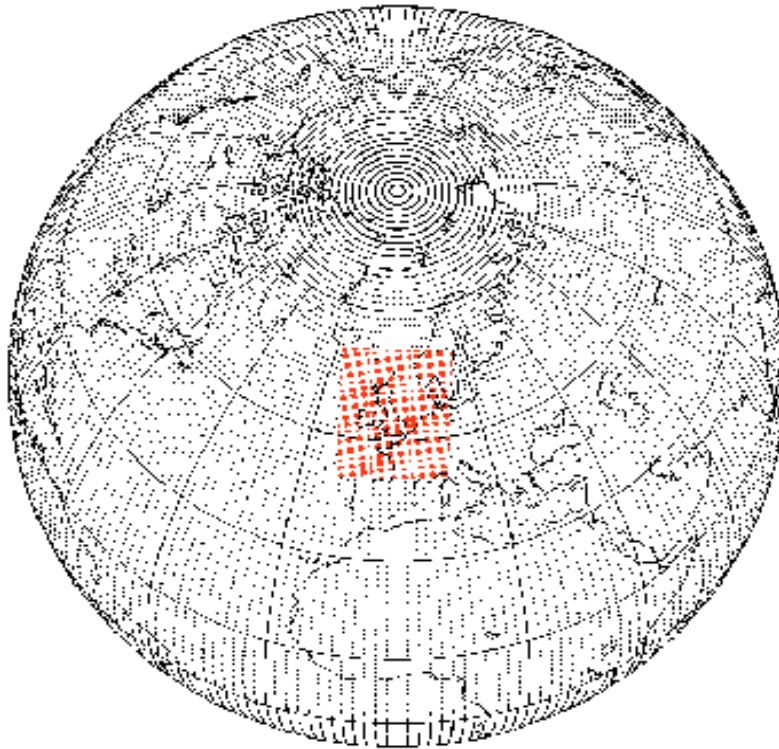
Figure 2: The grids used by the global and UK Mesoscale forecast systems.

Data Assimilation:
3DVar, FGAT, 6 hourly cycle
3hr cut-off with update
runs for next cycle

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Ob type	Notes	Global	UK Mesoscale
Synops	Surface Pressure	✔	✔
	U,V (land)	✘	✔
	U,V (sea)	✔	✔
	Temperature	✘	✔
	Relative Humidity	✘	✔
	Visibility	✘	✔
PAOBS	Australian BOGUS reports of PMSL. Trials indicate negative impact.	✘	✘
Drifting buoys		✔	✔
Aircraft	AIREPS, AMDARS	✔	✔
Sondes	TEMP, PILOT, Dropsondes	✔	✔
Satellite atmospheric motion winds	Meteosat-5 (IR,WV, VIS)	✔	✘
	Meteosat-7 (IR,WV, VIS)	✔	✔
	GOES-8 (IR)	✔	✘
	GOES-10 (IR)	✔	✘
	GMS-5 (IR,WV, VIS)	✔	✘
	Use of WV in clear air	✘	✘
Scatwinds	Locally processed ERS scatterometer winds	✔	✘
TOVS, ATOVS	Radiances rather than retrieved profiles used as of Oct 1999	✔	✘
Wind profilers	Aberystwyth site only. European and US sites being monitored.	✔	✔
SSM/I	10m windspeed	✔	✘
	Total column water vapour	✘	✘
MOPS		✘	✔

Table 3: Observing systems used or being assessed for use in the data assimilation system. A tick in the 3rd or 4th column indicates operational use.
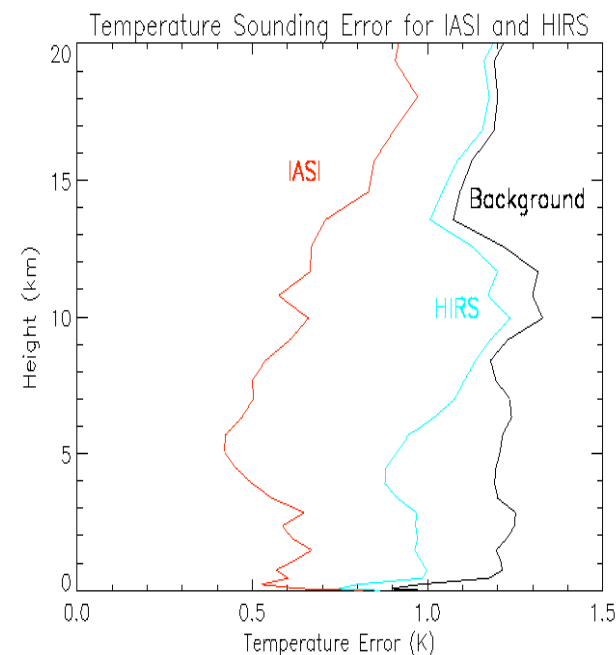
Why assimilate AIRS?

- **(A)TOVS radiances have large impact on forecast**
  - ~8-12 hrs improvements in NH; ~2 days in SH

- **ATOVS only influences large scales (~100km/3km**

- **As NWP models have more levels and lower f/c errors the need for higher vertical resolution and more accurate radiances is clear**

- **Experience gained with AIRS can be used for IAS and CrIS**

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HIRS (NOAA 15) Channels 1-10 and Typical IASI Spectrum

Temperature Sounding Error for IASI and HIRS
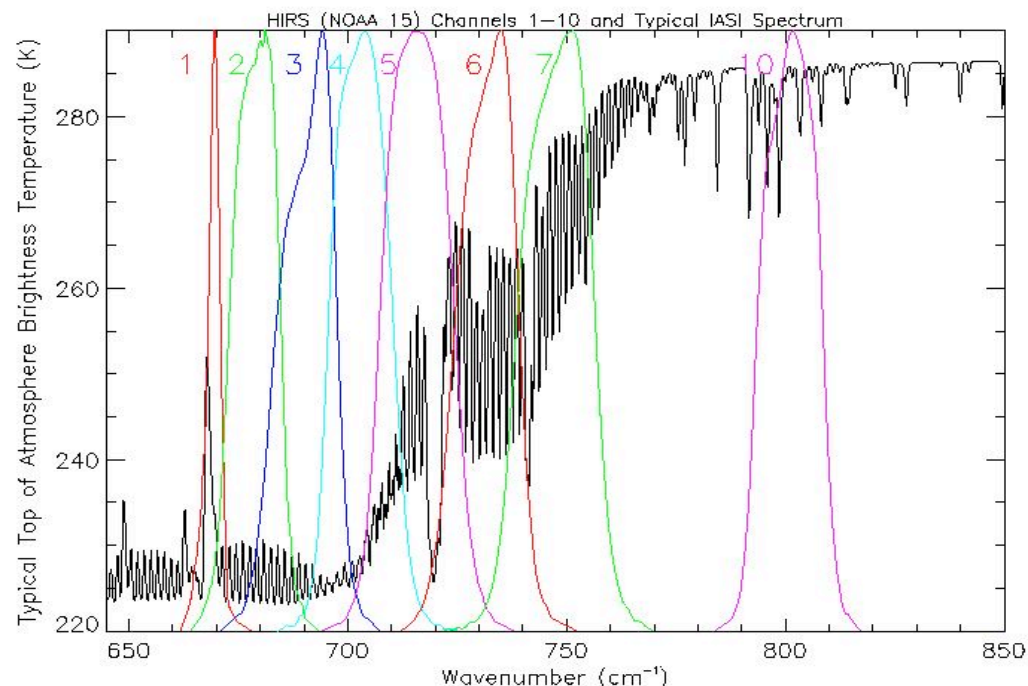
Black line shows IASI measured spectrum.
Coloured lines show HIRS channels

Simulated errors for IASI and
HIRS temperature profiles

Improved atmospheric temperature and constituent retrievals using the new
European high resolution atmospheric sounder (IASI)

AIRS data

- Near real time 1b data (<3hrs, calibrated, geolocated radiances) from NESDIS
  - Spatial sampling (1 AIRS in alternate AMSU-A fovs)
  - Spectral sampling (~228 channels)
  - Data volume in BUFR ~100Mbytes/day
  - EOF files for research
- Also AMSU-A/HSB data required as NOAA-16 backup
- Distribution to Europe via NESDIS-Bracknell link
- *Current ATOVS 1b data flow is model*

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Radiative Transfer Models

- AIRS line-by-line transmittances from UMBC

- Plan is to include AIRS capability within **RTTOV** to allow a unified code in NWP models

- **RTTOV** operationally used at ECMWF, MO, MF for radiance assimilation

    - Mixed gases, H_2O, O_3, surface and cloud top in profile vector

    - Surface emissivity fast models included

    - *N.B. Direct, Tangent Linear, Adjoint and Jacobians required for radiance or 1DVar retrieval assimilation*

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Issues for RT Models

- Speed how to assimilate 10% of AIRS channels?

- How to represent stratosphere/mesosphere in dependent profile set

- Number of pressure levels to use for AIRS calcs

- Impact of errors in Jacobians and RT model error correlations on assimilation

- Research into optimal water vapour predictors for AIRS (in progress)
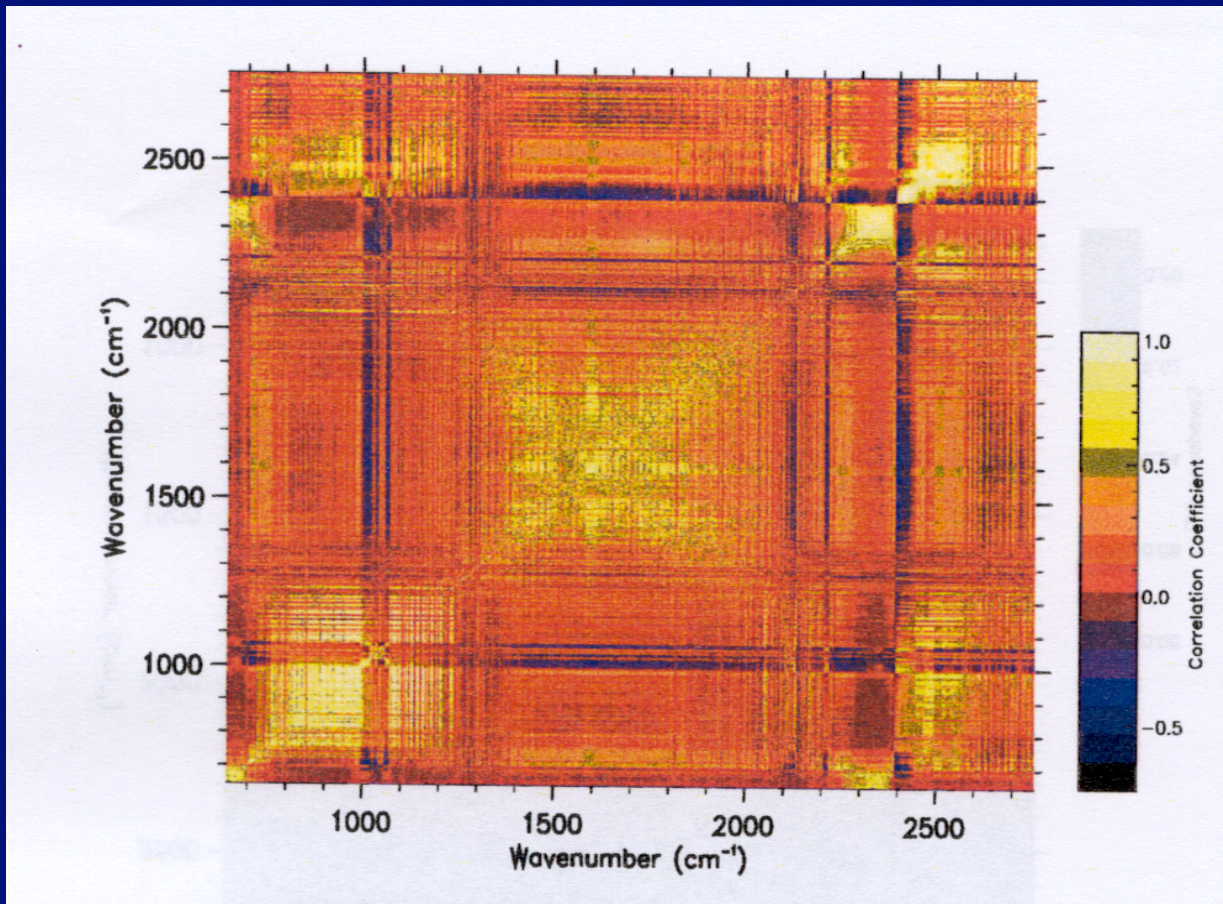
- Include other gases?

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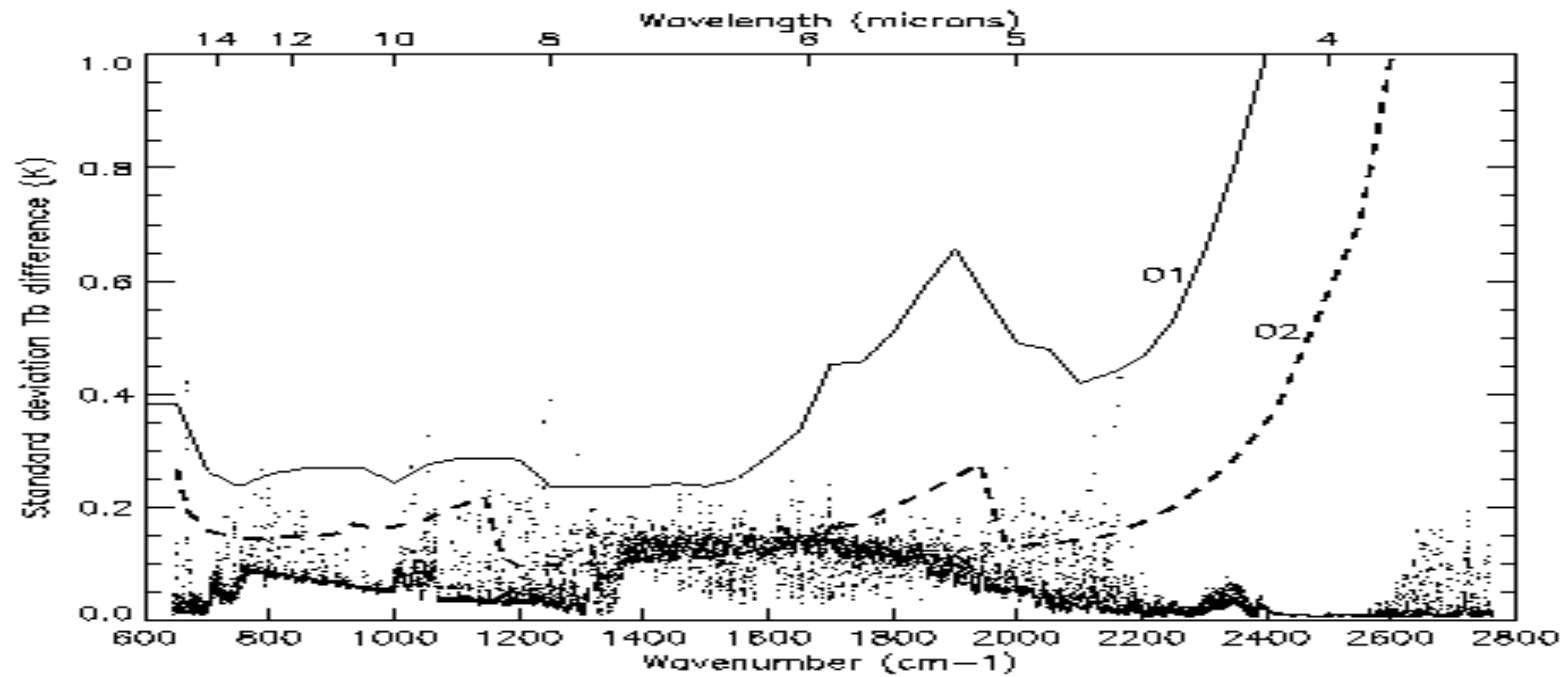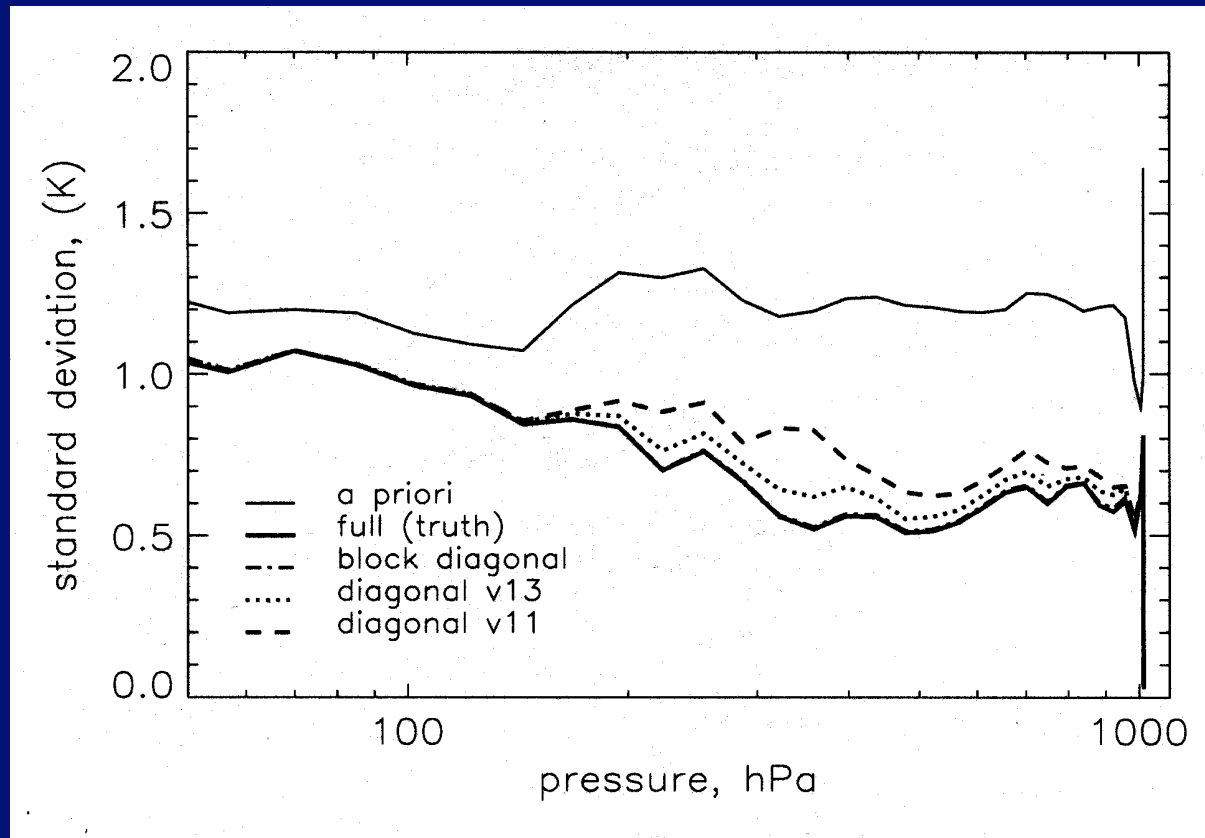
Accuracy of RTIASI fast model
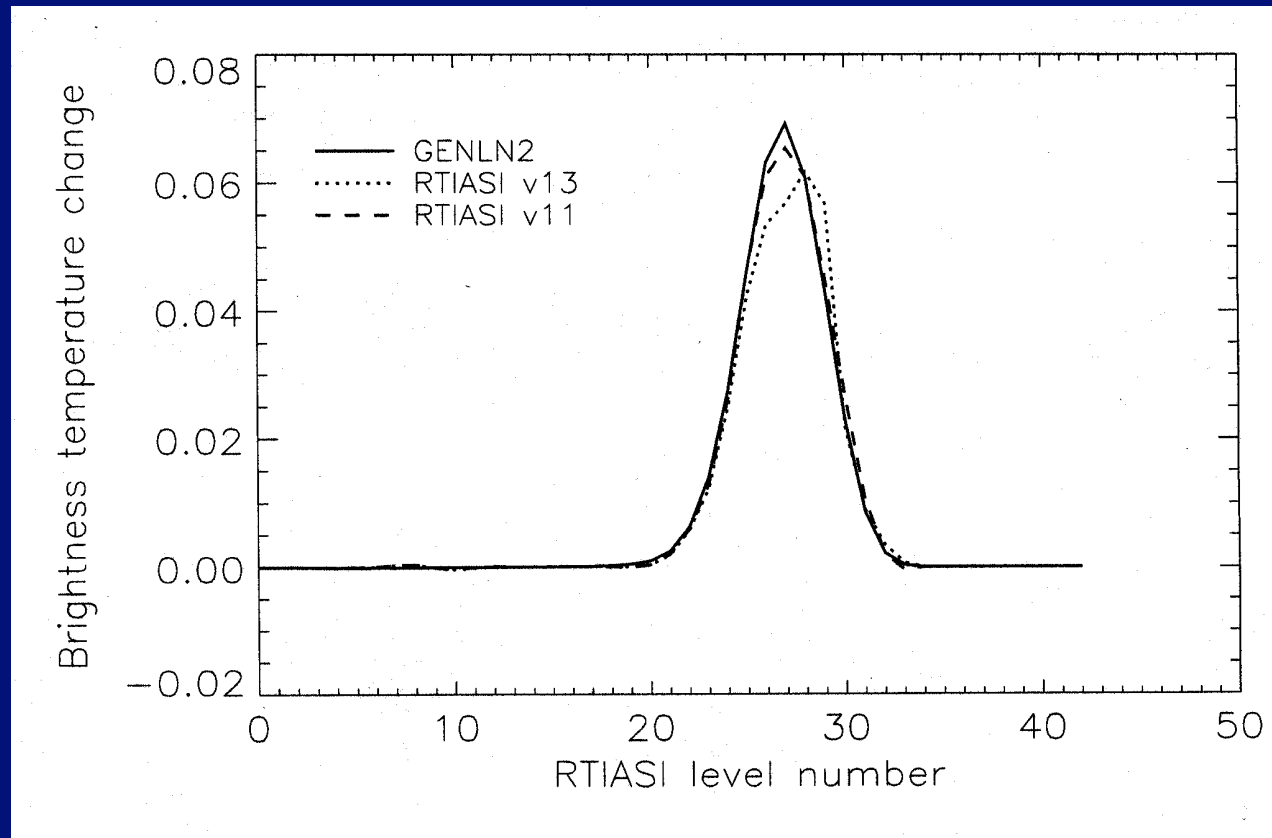
O1 is specified noise
O2 is latest estimate for IASI

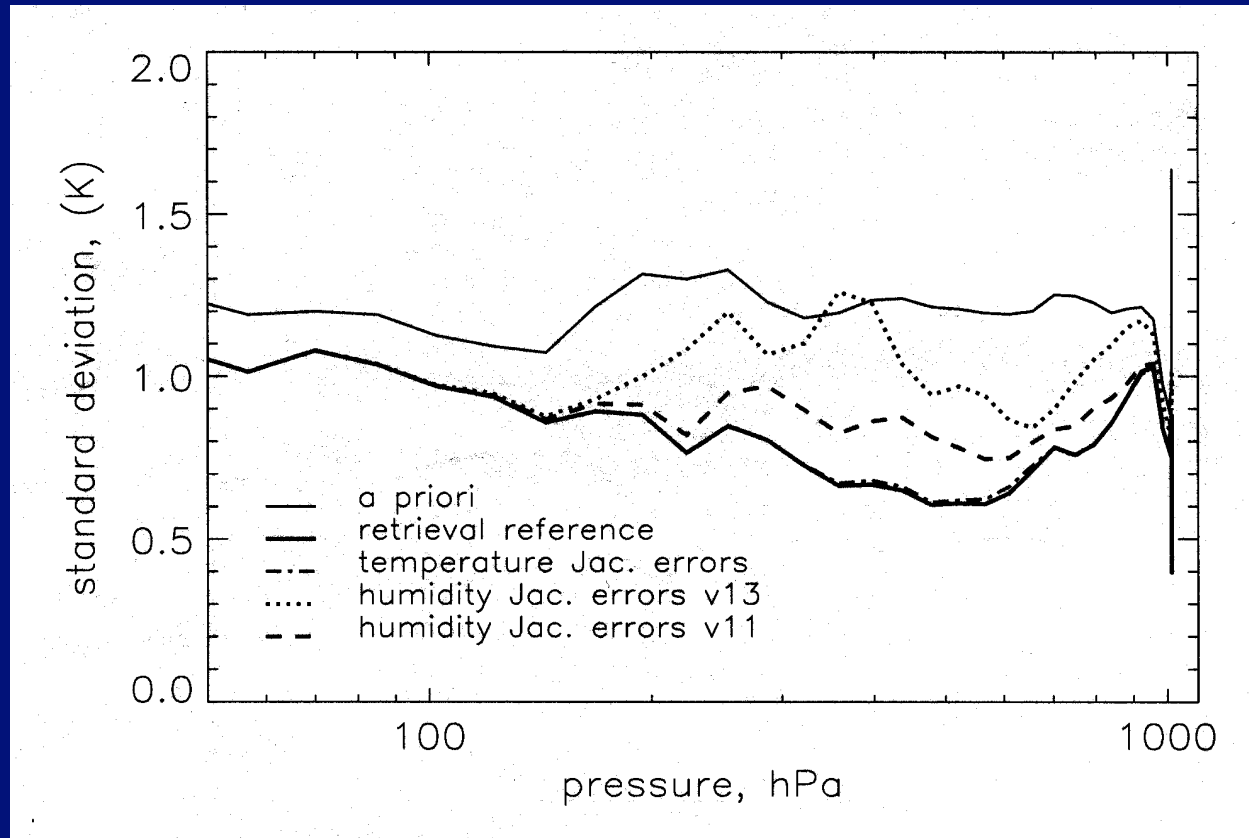# Forward model error correlation matrix for RTIASI

Effect of error correlation

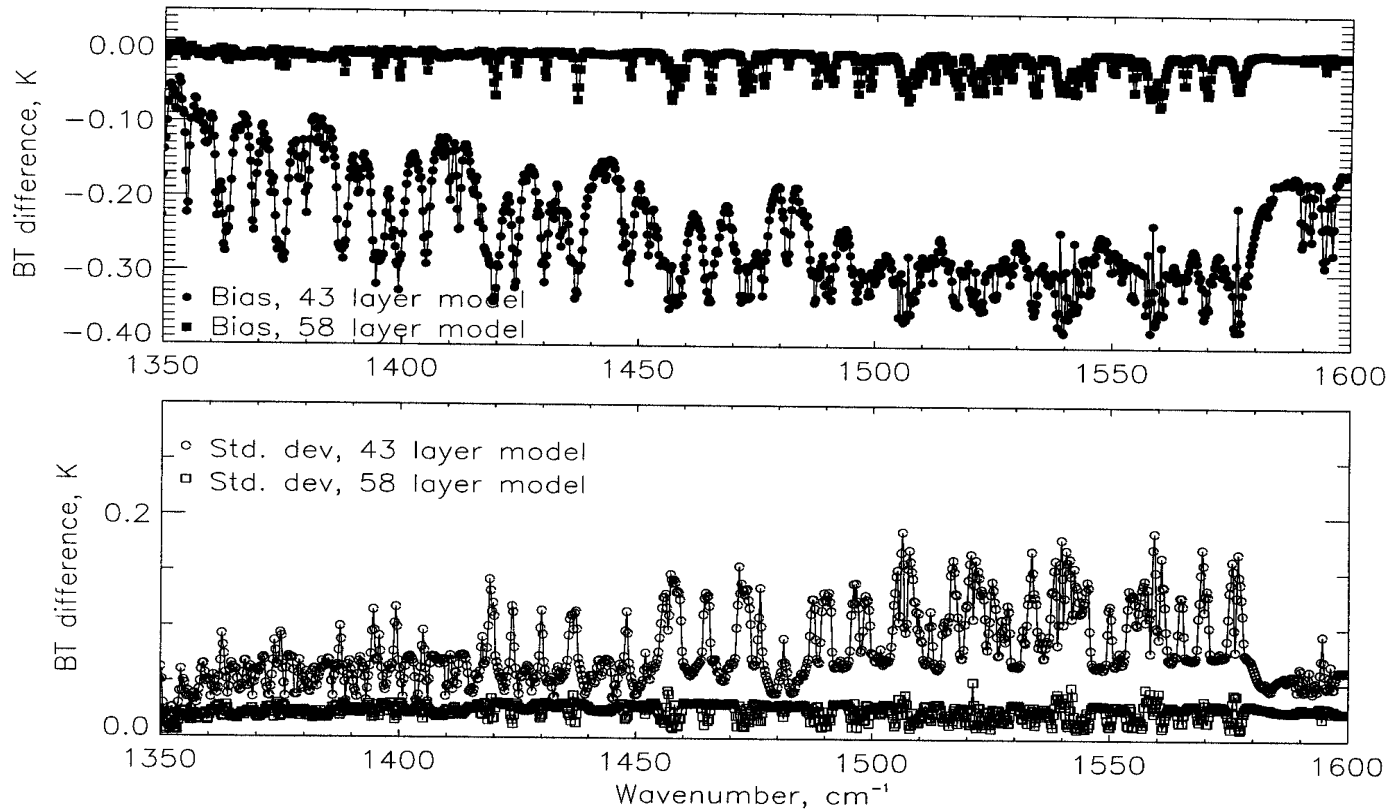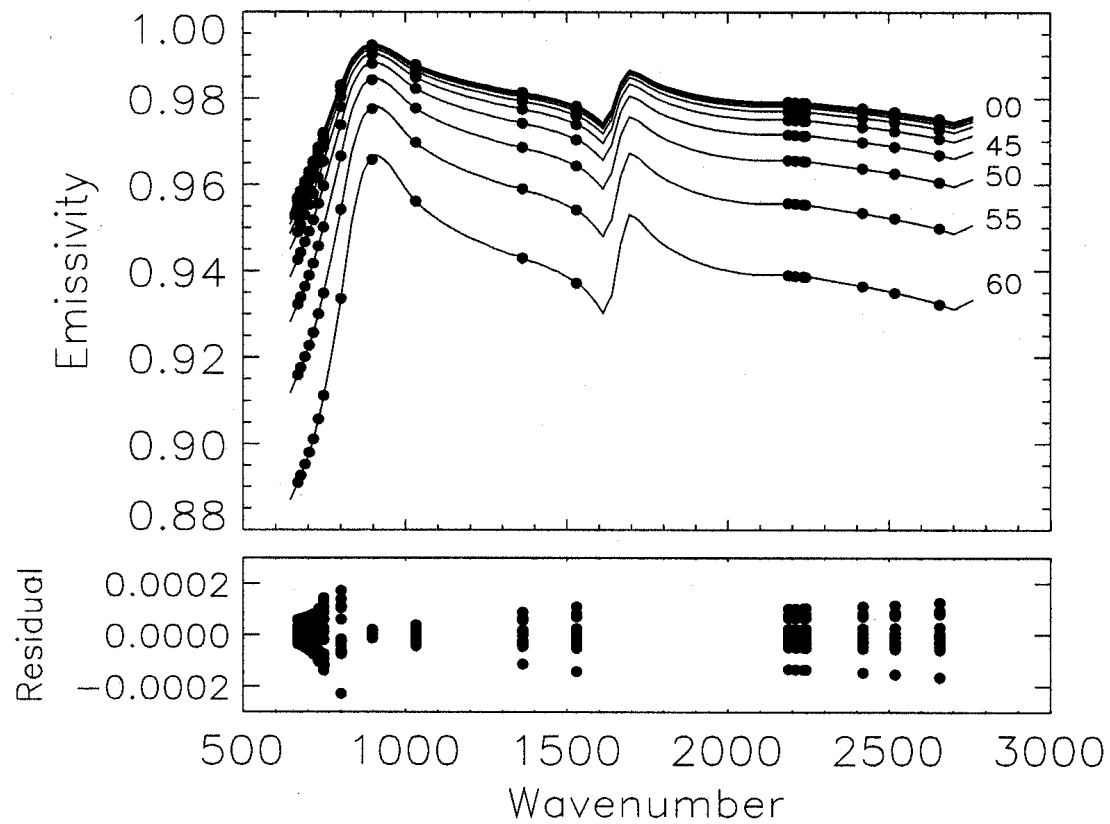# Example of bad wv jacobian

Effect of bad Jacobians

Number of RT model levels

Fast surface emissivity

AIRS processing

From NESDIS → **BUFR ingest**

To other European NWP centres

Pre-processing
Cloud detection, thinning,
q/c and bias correction

1DVar retrieval

Monitoring stats
radiances, retrievals O-B
no. of obs and q/c flags

3DVar assimilation
retrievals or radiances

Cray T3E supercomputer

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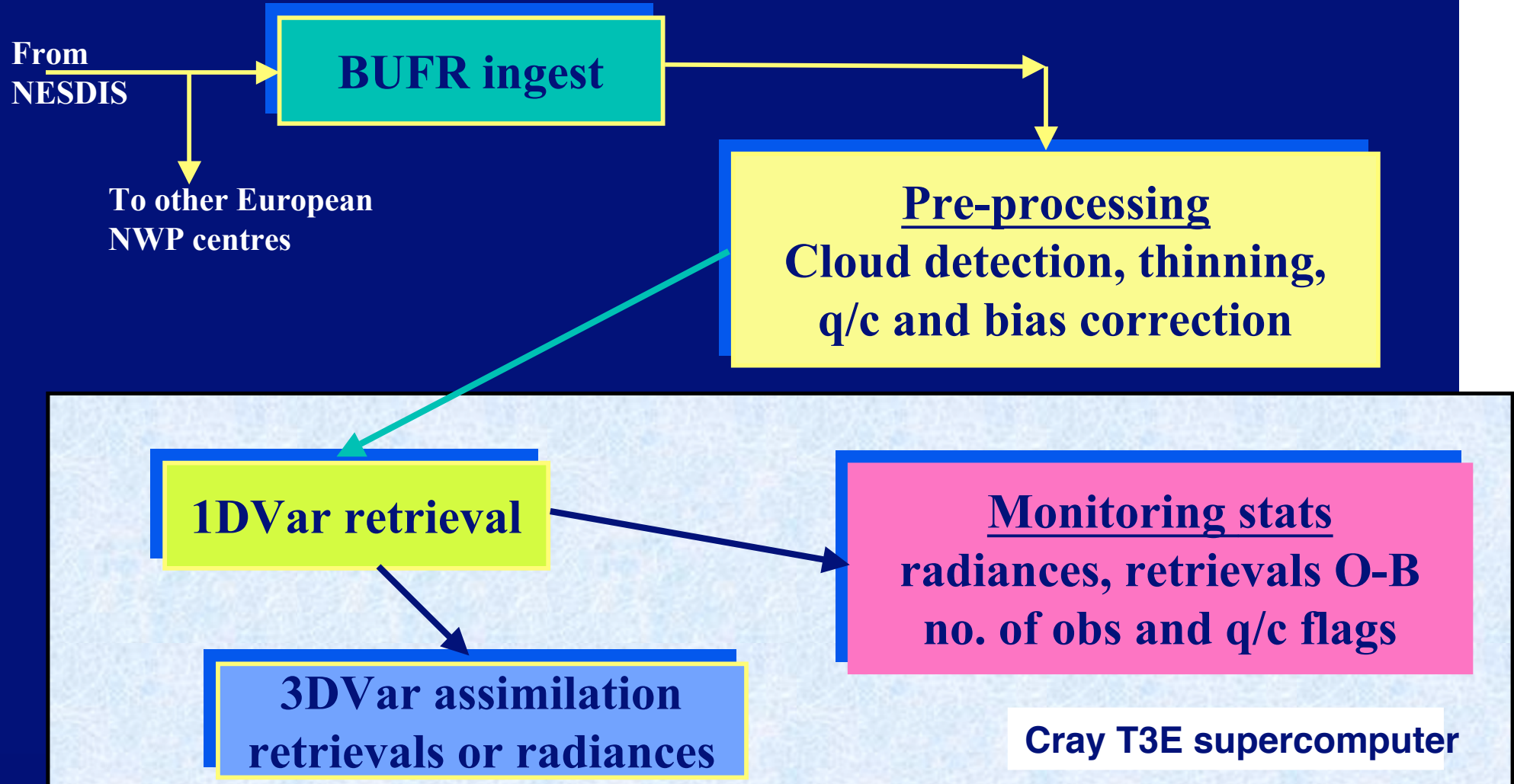
Variational Data Assimilation

x is state vector (*e.g. 1DVar: T(p), q(p),O_3,LWC(p), surface*)
J **is cost function**
y^o is radiance vector (*e.g. n AIRS radiances+AMSU/HSB*)
x^b is first guess state vector (*e.g. from NWP forecast*)
H is observation operator (*RT model + interpolation*)
R is observation error covariance matrix
**B is first guess error covariance matrix**

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Options for Data Assimilation

- **Assimilation of retrievals from NOAA or NASA**

  – $T(p)$, $q(p)$ later $O_3(p)$ *Lowest cost but inconsistent FG*

- **Assimilation of 1DVar retrievals**

  – $T(p)$, $q(p)$ later $O_3(p)$ *More optimal but recent experience shows significant gains with next option*

- **Direct radiance assimilation**

  – only 200 channels *Most expensive but most optimal and is current operational use of ATOVS*

  – Clear only (n.b. all stratospheric channels)

  – Later simple cloudy fovs

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AIRS impact assessment

- Radiance monitoring (are O-B stats reasonable?) compare with HIRS from NOAA-16

- Compare AIRS 1DVar retrievals with ATOVS and RAOB match-up profiles

- Look at analysis increments

    – Temperature and water vapour

- Look at forecast scores in range 1-5 days especially S. Hemisphere *verified against Obs and Analyses*

- **What is control?**

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ECMWF TOVS / ATOVS radiance data monitoring
GLOBAL LEVEL-1C (OBS-FG) radiance departure (in K) FOR NOAA-14 (sea/qc)
H=HIRS M=MSU A=AMSUA B=AMSUB large red characters indicate active use in analysis
solid blue = uncorrected / solid red = bias corrected / dotted red = +/- 1 standard deviation

Exp 0001
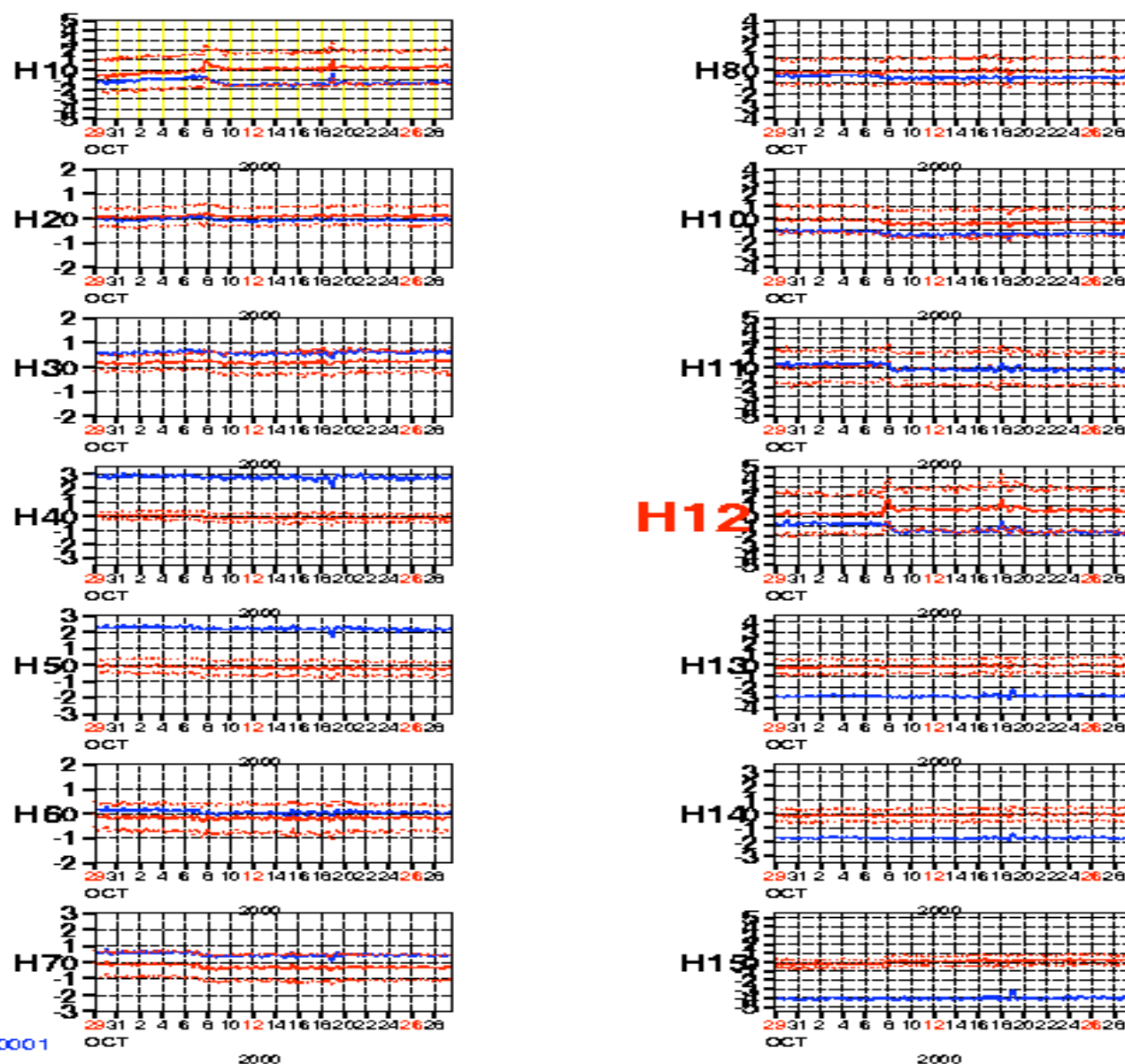
ATOVS - NOATOVS 3 day forecast errors for 500hPa Z

ATOVS Mean RMS T+72−ATOVS Analysis, 14th Jan. to 8th Feb. 99 − NOSAT Mean RMS T+72−NOSAT Analysis, 14th Jan. to 8th
Geopotential Height (m) at 500hPa

Mean: −2.9705E+00, RMS: 9.0847E+00, Max: 4.1097E+01, Min: −7.3527E+01
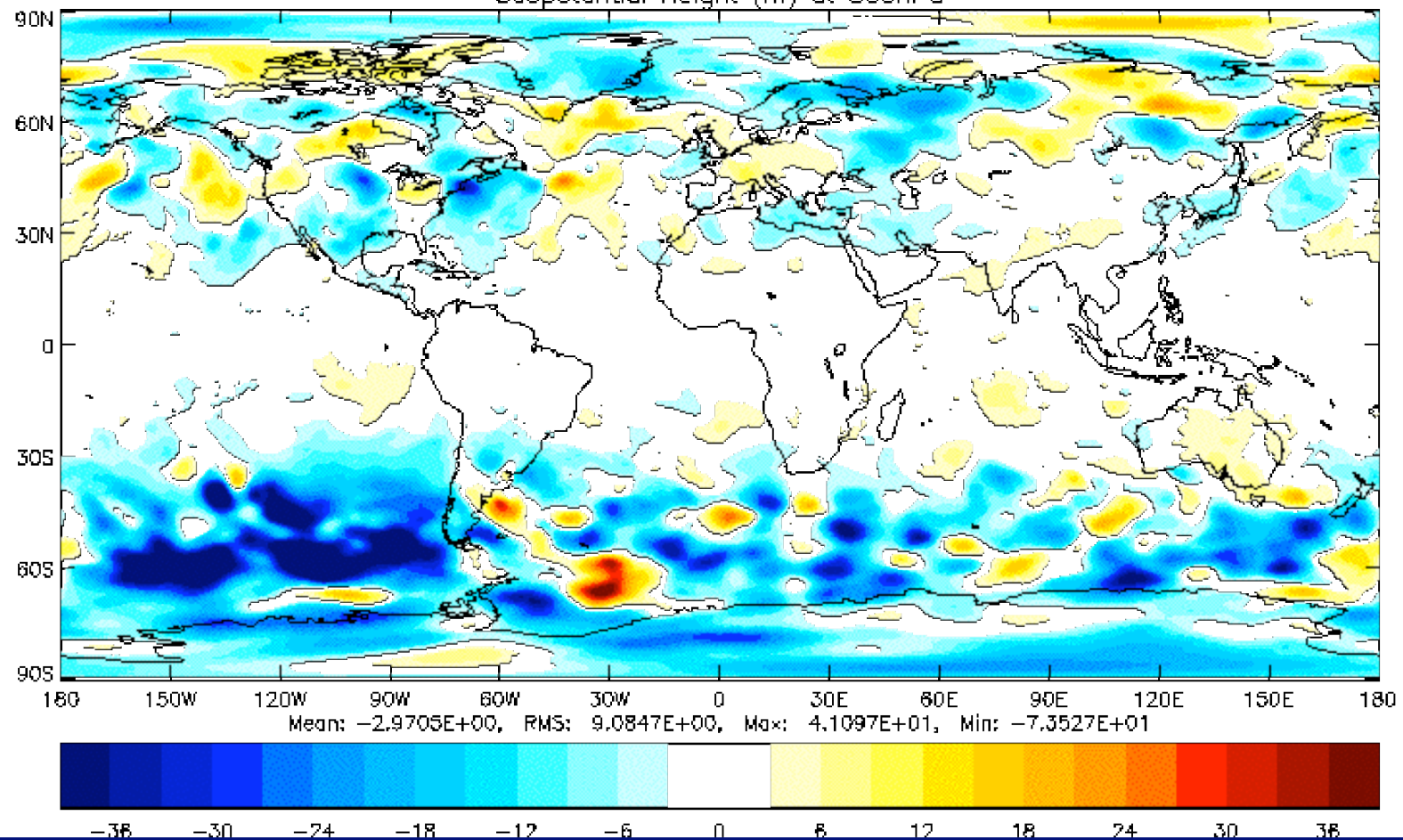
Project Milestones

Dec 2000 Define BUFR format

Jan 2001 Start transfers with simulated data

Apr 2001 Deliver version 1 of assimilation code

Launch + 3 months Start monitoring radiances

Launch + 9 months Start assimilation trials

Launch + 18 months Report results of trials

Launch + 24 months Operational assimilation?

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Key assumptions

- Calibrated located radiances available (no limb correction or bias correction applied) *within 3 hours of measurement time*

- Radiance biases are stable to less than noise

- Data flagged not modified (e.g. cloud detection)

- Data available ~3 months after launch

- Continuity of data > 1 month for all seasons

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That's it!

Thank you for your attention

Any questions?

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